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COLLABORATIVE ANALYSIS OF SOLAR MAXIMUM MISSION, VENERA, AND PROGNOZ SOLAR X-RAY BURSTS

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Final Technical Report for Grant NAG5-935

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One of the prime objectives of this investigation was to compare SMM-HXRBS data with Venera data for the same solar flare X-ray events, in order to search for rapid fluctuations in the time histories, and to establish limits for the anisotropy of the X-ray emission. The latter objective was to be carried out for those solar events for which the HXRBS/Sun/Venera angle was relatively large. In order to accomplish these objectives, a careful cross-calibration of the HXRBS and Venera detectors was required. Such a cross-calibration should be carried out on a number of solar events satisfying two criteria:

1. The events should be those for which the HXRBS/Sun/Venera angles were small, so that the effects of anisotropic emission (if any) could be assumed to be negligible.
2. The events should display a rather wide range of energy spectra, so that any systematic effects in the comparison procedure could be identified.

A cross-calibration was first attempted for the event of February 5, 1982. This flare satisfied criterion 2 above, but not criterion 1. The time history was divided up into six intervals. For each interval the observed HXRBS and Venera energy spectra were converted to photon spectra, and a single power law spectrum was fit to the resulting composite photon spectrum. For some intervals, the fit was quite good, while for others, it was quite poor. The reasons for this were not clear, but there were several flaws in this simplified cross-calibration procedure:

1. The event had an HXRBS/Sun/Venera angle of 60°. Although any anisotropy was expected to be small, this flare was clearly not an ideal test case.
2. The cross-correlation between the HXRBS and Venera time histories was not as accurate as it could be; the induced errors, however, were felt to be well below those observed.
3. The fitting procedure was oversimplified. The HXRBS and Venera spectra were deconvolved separately, and a power law fit was then carried out. A more correct procedure would be to fit the power law simultaneously to the two data sets.

The Principal Investigator has met twice with HXRBS scientists (R. Schwartz and D. Zarro, Applied Research Corporation, and B. Dennis, Goddard Space Flight Center) since the formal expiration date of this grant, in order to refine the data comparison methods and rectify the three problems above. The following progress has been made:

1. We have gone through the long list of HXRBS and Venera solar flares, and identified 20 for further study, based on the HXRBS/Sun/Venera angle (Table 1). In addition we have found eight flares which were observed in partial occultation by either HXRBS or Venera (Table 2), and several flares which were observed by both HXRBS and Venera, for which the SMM-GRS observations indicate anisotropic emission.
2. We have developed and tested a code which allows the HXRBS and Venera time histories to be cross-calibrated with an accuracy of several milliseconds. This code operates by taking the arrival time at one spacecraft (e.g., HXRBS), propagating it back to the Sun (to a specific active region whose position is known to within several degrees), and then propagating it back out to the Venera spacecraft.
3. We have found that a joint spectral fitting code was developed for HXRBS and HXIS data. This code (called the DCP, or Data Comparison Procedure) is relatively easily modified to substitute Venera for HXIS. The modification involves replacing the HXIS response matrix with the Venera response. This has been done for a single test case (a set of power law spectra for the Venera 13 spacecraft). Ultimately, the new code will have to contain both Venera 13 and Venera 14 response matrices as a function of time, for power law spectra. (The time-dependence arises due to detector gain drifts over the mission lifetime). In order to obtain the Venera 13 and 14 response matrices, we have had to migrate a spectral fitting program from Toulouse, to a 386 PC in Berkeley. This has turned out to be a very time-consuming procedure, since the original program was written in a version of Turbo Pascal which is no longer supported. The program required modification, and in order to do this, it was first necessary to upgrade it to Turbo Pascal 5.5. Six months of part-time programming effort were required, and the program was completed in June 1991.

To summarize the progress in this study:

1. The problem has proven to be considerably more complex than we had anticipated intially; simplified comparison procedures are inappropriate.
2. A rigorously correct comparison procedure has been identified and is being implemented.
3. Work is continuing on this project, funded by other sources, and we anticipate significant progress and possibly completion over the next six months.

Table 1. Stereoscopically Observed SMM/Venera Events Detected as Gamma-Ray Flares

Yr	Start Mn	Start Dy	UT Hr	UT Mn	Duration Mn	Duration S	Intensity/Position GOES	H_α	Lat	CMD	View Angle S	View Angle V	View Angle D
81	11	1	18	12	7	0	M1.6	SB	S14	E38	38	38	0
81	11	5	8	33	6	0	M3.5	SB	S10	W11	11	11	0
81	11	22	3	22	0	49	M1.2	1B	S20	W72	71	69	2
82	1	28	6	58	40	0	M8.8	3B	N9	E45	47	52	5
82	2	8	12	45	12	0	X1.4	1B	S13	W88	87	78	9
82	2	12	21	55	7	0	M3.6	SB	S8	W18	19	9	10
82	4	2	9	4	5	0	M6.7	2B	N9	W62	62	16	46
82	4	16	21	23	3	0	M2.5	SN	S4	W90	90	39	51
82	6	20	1	13	0	0	M1.0	SB	N13	W27	27	33	6
82	6	26	0	44	20	0	X1.9	2B	N16	W65	64	16	48
82	7	17	2	5	10	0	M8.5	1B	N14	W23	24	34	10
82	11	22	12	22	0	26	M2.0	SB	S10	W33	33	4	29
82	11	26	2	26	12	0	X4.5	2B	S22	W87	85	53	32
82	12	7	23	37	20	0	X2.8	1B	S19	W86	84	49	35
82	12	13	3	23	14	0	M8.3	2B	S9	E51	51	90	39
82	12	15	16	29	15	0	X5.0	2B	S10	E15	15	55	40
82	12	17	1	43	7	0	M4.8	1B	S10	W03	7	42	35
82	12	17	18	50	10	0	X9.9	3B	S8	W21	21	21	0
82	12	18	8	20	8	0	X1.2	1B	S10	W20	20	23	3
82	12	30	1	40	5	0	M7.1	2B	S13	W22	23	28	5

Table 2. Partially Occulted SMM/Venera Events

Yr	Start Mn	Start Dy	UT Hr	UT Mn	Duration Mn	Duration S	Intensity/Position GOES	H_α	Lat	CMD
81	12	15	19	45	2	0	M3.5	SB	N18	W90
82	2	9	13	59	18	0	M9.5			W95
82	4	16	21	23	3	0	M2.5	SN	S4	W90
82	6	2	15	29	6	0	M9.9	1B	S8	E83
82	6	3	11	48	18	0	X8.0	2B	S9	E72
82	7	12	9	8	60	0	X7.1	3B	N12	E39
82	12	13	3	23	14	0	M8.3	2B	S9	E51
82	12	13	8	3	14	0	M5.2	2B	S12	E51